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JPRS-JST-86-015

3 JUNE 1986

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Japan Report

SCIENCE AND TECHNOLOGY

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JPRS-JST-86-015

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JAPAN REPORT

SCIENCE AND TECHNOLOGY

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NATIONAL SPACE DEVELOPMENT AGENCY'S SURVEY ON SPACE MATERIALS

Tokyo NIKKO MATERIALS in Japanese Mar 85 pp 14-17

[Article: "From the Survey of the National Space Development Agency of Japan--Development of Space Materials Also Enters Commercialization Age!?"]

[Excerpt] It Is Profitable To Develop Space Materials

This investigation has been carried out for the following two purposes: 1) To prepare basic data for studying the Japanese space station project, and 2) to study whether or not Japan's participation in the U.S. space station project will be cost effective with consideration to future projects developing from the present project.

Definitively, Japan's future space activities which will start with participation in the U.S. space station project have been examined, the cost of the Japanese space station project (estimation) has been analyzed, and the anticipated effectiveness of the Japanese space station project has been systematically studied. Also, items which can be considered to be exceedingly large matters for Japan--that is, the formation and development (space manufacturing field) of new space industries--are being studied. In this case, domestic and foreign literature was surveyed, the relation between cost and effectiveness was tentatively studied by quoting the analyzing method used in the United States, and case studies were conducted to study the marketability of space manufactured goods. In addition, this project was evaluated from the analytical standpoint of cost and effectiveness.

By the way, prior to this project, the National Space Development Agency of Japan (NSDAJ) had conducted space material processing experiments for Japanese space research and development six times during the period from 1980 to 1983 by using the Type-TT-500A rocket in cooperation with the Institute of Physical and Chemical Research, the National Research Institute for Metals and the National Institute for Research in Inorganic Materials. Thanks to these experiments, NSDAJ has succeeded in manufacturing the silicon arsenide telluric (SiAsTe) amorphous semiconductor, monocrystalline semiconductor, and nickel titanium carbide (NiTiC) serial composite alloy, and in obtaining materials possessing characteristics superior to those of materials being manufactured on the ground. The study of this investigation is based on these data.

Electronic and Biomaterials Are the Most Promising

As a result of the investigation, the following items can be considered to be the main materials which will be used in the most promising space manufacturing field.

(1) Semiconductor materials and electronic materials compound semiconductors (optoelectronics, solid laser material, and high-speed operating semiconductors)

Amorphous electronic material (optoelectronic material)

Superconductive material (ferromagnetic field generating superconductive magnet)

High-performance magnetic material (compact, accurate, and high-performance magnet)

Super-perfect crystal (standard single crystal for researching physical properties)

(2) Biomaterials

Protein such as enzymes, hormones, etc., (pharmaceuticals and research reagent)

Biological cells (pharmaceutical manufacturing cell and research cell)

(3) Optical materials

Optical laser glass (large output laser and infrared wave guide)

High-strength ceramics (corrosion-resistant and high-strength material, wear-resistant and high-strength material, and heat-resistant and high-strength material)

Lamellar ceramics (precise processing tool and ultra LSI--large-scale integrated circuit--substrate)

(4) High-function alloy and metal composite material

Directionally solidified alloy (high-temperature and high-strength alloy material)

Unmixed alloy (vibration absorbing alloy material, bearing material and superconductive material)

Metal composite material (high-temperature and high-strength material and aircraft material)

Table 1. Example of New Semiconductor Materials Expected To Be Manufactured in Space

Material	Use	Present status	Effectiveness expected by manufacturing materials in space
Lead and tin tellurium (PbSnTe) single crystal	High-speed operation semiconductor element (High-speed computer) Laser element in far-infrared region (Optical communication system) Sensor element in far-infrared region (Remote sensing, gas sensor element, etc.)	Although laser elements in the far-infrared region have good reproducibility and their movements are stable, the development plan for them has not been determined.	It is said to be difficult to manufacture large-sized, high-quality single crystals on earth because of heat convection in melted liquid, specific gravity difference between mixed substances, etc., but it is expected that such single crystals can be manufactured by making the most of a characteristic, i.e., weightlessness.
Mercury cadmium tellurium (HgCdTe) single crystal	Sensor element in infrared region (Artificial satellite, optical communication system, etc.)	It is expected that the mercury cadmium tellurium single crystal will bring about elements with higher sensitivity and reliability and longer life as a material of sensor elements in the far-infrared region than any other substance.	
Aluminum gallium arsenide (AlGaAs) single crystal	Laser element in visible region (Optical communication system and laser disk light source)	It is believed for the time being that InP is used in the same way as AlGaAs, but it is expected that this material--i.e., the AlGaAs single crystal--will bring about higher quality elements.	
Indium gallium arsenide (InGaAs) single crystal	High-speed operation semiconductor element (High-speed computer) High-sensitive magnetic sensor element (Computer memory device)	It is believed for the time being that GaAs is used as a semiconductor element which replaces silicon IC (integrated circuit), but it is expected that this material--i.e., the InGaAs single crystal--will bring about higher quality elements.	
Silicon arsenide tellurium (SiAsTe) amorphous	High-effective solar battery Sensor element in visible infrared region (Optical communication system)	The SiAsTe has come into the limelight, because the ratio of components or organic elements can be changed, etc., but the best of this characteristic cannot be made, because this material is liable to be uneven when it is manufactured on earth.	Although it is difficult to manufacture the large-sized, high-quality amorphous on earth, it is expected that such amorphous can be manufactured in space.

Table 2. Example of Biomaterials Expected To Be Manufactured in Space

Biomaterial	Use	Present status	Effectiveness expected of manufacturing materials in space
Beta-cell	Cure for diabetes (transplantation of cells or production of insulin by use of cells)	After the viscera, etc., of animals have been collected, crushed, and dissolved, the purposed clels are extracted by way of multistage and complex segregating and refining processes. However, it is inefficient and difficult to mass-produce these cells, because high technology is required for segregating them up to the cell stage on earth.	It is expected that these cells will be mass-produced by sorting cells electrophoresced in a weightless state and by suspending and cultivating cells.
T cell and B cell	Immunotherapy		
Urokinase producing cell	Therapeutic agent for preventing thrombosis (cure for cerebral thrombosis)		
Urokinase	Therapeutic agent for preventing thrombosis (cure for cerebral thrombosis)	After the pretreatments--that is, biomaterials such as viscera, etc., of animals have been crushed and dissolved--multistage segregation processes are required for segregating and refining a very small amount of protein contained in the biomaterials, by using segregation technologies such as centrifugation, salting-out, chromatography, etc. For this reason, it is inefficient and difficult to mass-produce these materials on earth.	It is expected that these materials will be mass-produced by segregating and refining cells electrophoresced in a weightless state.
EGR (epidermal growth factor)	Agent for promoting epidermal cells (cure for burns, etc.)		
Parathyroid hormone	Cure for abnormal bone		
Growth hormone	Cure for hypopituitarism and dwarfism		
Nerval growth factor	Recovery of nerves after undergoing a surgical operation		

(5) Polymeric organic material

High-strength organic composite material (automobile lightweight material and medical organic material)

Environment-resistant; high polymer molecule (space structural material, high-heat resistant resin, and radiation protection resin)

Precise shaped high polymer molecule (latex sphere with a uniform diameter)

Tables 1 and 2 show the details of the highly expected new semiconductor material and biomaterial of the above-mentioned materials.

Space is a world controlled by weightlessness, vacuum close to perfection, extremely high temperature, cryogenic temperature, a large amount of cosmic rays, and nearly boundless solar energy. In any case, special conditions can be simultaneously obtained in space, although these conditions cannot be realized on earth except at enormous cost.

For example, lead and tin tellurium (PbSnTe) single crystal, mercury cadmium tellurium (HgCdTe) single crystal, aluminum gallium arsenide (AlGaAs) single crystal, indium gallium arsenide (InGaAs) single crystal, silicon arsenic tellurium (SiAsTe) amorphous, etc., can be cited as semiconductor materials, and beta cell, T-cell, B-cell, urokinase producing cell, urokinase, EGR (epidermal growth factor), parathyroid hormone, growth hormone, nerval growth factor, etc., can be cited as biomaterials. It is expected under the above-mentioned environment that these materials can be relatively easily mass produced because they are mainly advantageous in a weightless state.

Cost of Semiconductor Materials Is Y94 Billion

The investigation has estimated the sales of space products such as these semiconductor materials and pharmaceuticals which will be manufactured in Japan in 2000. The estimate method is as follows. The sales of Japanese space manufacturing articles are calculated on the basis of the sales (estimated in the United States) of each U.S. space manufacturing article in 2000 with consideration to the ratio of Japanese industrial scale to the U.S. scale (present sales scale) and the U.S. precedent factor. The propriety is checked in light of the Japanese production amount estimated at the same time (in 2000).

In the case of semiconductor materials, it has been estimated that the amount of U.S. space manufacturing sales in 2000 is Y450 billion, and assuming that the rate of Japanese industrial scale to the U.S. scale is 63 percent and the U.S. precedent factor ratio is 3:1, the amount of Japanese space manufacturing sales will be Y94 billion. The estimated amount of new Japanese semiconductor materials which will be produced at this point in time will be Y770 billion, and the rate of space manufacturing products to all products will be 12 percent, which is within a proper scope.

Although it is extremely difficult to estimate the amount (Y92 to 690 billion) of the U.S. space manufacturing sales concerning pharmaceuticals, assuming that the amount is Y390 billion, the industrial scale ratio is 62 percent, and the U.S. precedent factor is 3:1, it is estimated that the amount of Japanese space manufacturing sales will be Y80 billion annually. At this point in time, it is anticipated that the amount of products brought about by biotechnology in Japan will reach Y2 trillion and the space manufacturing rate will be 4 percent.

Estimate of Effectiveness Against Cost

With regard to the estimate of effectiveness against cost, a typical premise scenario concerning future space manufacturing development is hereunder determined in order to estimate the effectiveness which will be brought about by the space manufacturing work.

The expansion of facilities consists of three steps, i.e., Phases 1, 2, and 3. Actually, it consists of further complex steps. However, this method (three steps) has been adopted in order to simplify models. With regard to the only biomaterials and semiconductor materials which are considered to be most liable to be presently taken on the commercial base, presently known parameters of urokinase and EGF as biomaterials and those of HgCdTe, InGaAs, and AlGaAs as semiconductor materials have been used in the space manufacturing field for the purpose of estimating effectiveness.

The effectiveness is estimated by using the following estimating equation:

$$\text{Effectiveness} = \boxed{\begin{array}{l}\text{Value of materials which}\\ \text{can be manufactured in}\\ \text{space}\end{array}} - \boxed{\begin{array}{l}\text{Cost required for}\\ \text{manufacturing mate-}\\ \text{rials in space}\end{array}}$$

(Estimated by the manufacturing capability and market value of materials)

Also, with regard to Phases 1 and 2 for the expansion of facilities based on the premise scenario, Japanese modules will be used with a view to making manufacturing units larger from 1992 to 1995 and from 1995 to 2000, respectively. In addition, concerning Phase 3, such expansion subsequent to 2000 has been assumed, and full-scale space factories will be constructed.

According to the estimate, in Phase 1, the annual cost (except for participation cost) required for space manufacturing work will be Y3.3 billion, while the value of materials which can be manufactured in space will be Y2.1 billion. It will not be effective--that is, it will be below cost--because the annual cost will surpass the value. In the case of Phase 2, however, the annual cost will be Y9.7 billion, while the value will be Y22.7 billion. It will be completely profitable.

The estimate also indicates that in Phase 3 subsequent to 2000, the annual cost will be Y93.9 billion, while the value will be Y151.8 billion. Therefore,

Table 3. Artificial Satellites, etc., Scheduled To Be Launched After April 1984

	Satellite name	Weight (kg)	Orbital altitude (km)	Rocket launched	Launching FY	Main launching purpose
Satellite in scientific field	Test satellite MS-T5	About 125	Solar cycle	M-3S II	1984	To check the performance of the M-3S II and to preliminarily observe the plasma and Halley's comet.
	10th scientific satellite PLANET-A	About 125	Solar cycle	M-3S II	1985	To carry out from the earth research on plasma among innerside planets and to carry out observation and research on Halley's comet in the ultraviolet region.
	11th scientific satellite ASTRO-C	About 400	Circle 500	M-3S II	1986	To precisely observe the core X-ray source of the active Milky Way and multiform X-ray celestial bodies.
	12th scientific satellite EXOS-D	About 300	Ellipse 400/ 10,000	M-3S II	1988	To observe the electron density, corpuscular beam, plasma wave, etc.
Satellite in practical field	Geostationary meteorological satellite No 3 GMS-3	About 300	Geostationary orbit	N-II	1984	To improve meteorological work and to carry out the development of technology concerning meteorological satellites
	Broadcasting satellite No 2 BS-2b	About 350	Geostationary orbit	N-II	1985	To carry out the development of broadcasting satellite technology and to solve the difficulties in audiovision of television.
	Marine observation satellite No 1 MOS-1	About 750	Solar synchronous 900	N-II	1986	To establish the technology common in artificial satellites for observing marine phenomena and earth.
	Technical test satellite Type V ETS-V	About 550	Geostationary orbit	H-I Three-step tester	1987	To check the performance of the H-I rocket (three-step) tester, to establish the basic technology of geostationary triaxial satellite bus, to accumulate the independent technologies necessary for developing the next generation practical satellite, and to conduct communication experiments on mobile bodies.
	Primary material experiment FMPT	--	--	Space Shuttle (U.S.)	1987	To conduct material experiments, etc., in space using the Space Shuttle carrying a Japanese scientific engineer.
	Communication satellite No 3 CS-3a CS-3b	About 550	Geostationary orbit	H-I	1987 (CS-3a) 1987 (CS-3b)	To continue communication service by using communication satellite No 2, to cope with the demand for increasing and multiform communication work, and to carry out the development of technology concerning the communication satellite.
	Broadcasting satellite No 3 BS-3a BS-3b	About 550	Geostationary orbit	H-I	1987 (BS-3a) 1990 (BS-3b)	To continue communication service by using the broadcasting satellite No 2 to cope with the demand for increasing and multiform communication work, and to carry out the development of technology concerning the broadcasting satellite.

(Science and Technology White Paper for Fiscal 1983)

the difference (Y57.9 billion) between the annual cost and value can be obtained as effectiveness. The contents of the cost are as follows: The space factory construction cost is Y33 billion, the raw material transportation cost is Y27.4 billion, manufacturing unit development and production cost is Y11.2 billion, and other cost is Y22.3 billion. Also, the value of semiconductor materials is Y91.8 billion and of biomaterials is Y60 billion. If the above-mentioned effectiveness is realized, the balance between revenue and expenditure will be kept evenly at worst with consideration to the cost of participating in the U.S. space station, etc. Even if from the standpoint of the commercial base, the projects can be regarded as considerably profitable enterprises.

However, these projects require a large amount of investments at the initial stage, have many ambiguous points concerning expected effectiveness at present, and have many problems which must be solved in the future. For these reasons, it would be necessary to consider that the space station project and the space manufacturing field as a part of the project should be promoted as a key technology in the future development of space activities, aside from the "profitability."

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PROGRESS IN FIFTH GENERATION COMPUTER PROJECT SUMMARIZED

Tokyo DENSHI KOGYO GEPPO in Japanese No 9 Vol 27 pp 29-34

[Article by Takashi Ichikawa, general manager, General Affairs, Institute for New Generation Computer Technology: "ICOT's Trends--Outline of the Fifth Generation Computer Development Project"]

[Text] 1. Preface

The Fifth Generation Computer Development Project is a 10-year project initiated by the MITI in 1982 as part of its informationalization policy. Actual R&D has mainly been conducted by the Institute for New Generation Computer Technology (hereafter referred to as ICOT) with cooperation of universities, national and public research organizations, and computer manufacturers.

The current status of development is that the basic technology research in the initial 3-year phase has been completed roughly as planned, and work has commenced for the intermediate phase with a goal to conduct R&D on subsystems of the fifth generation computers. Steps were taken to overcome the turning point in the project by revising the organizational structure, considerably increasing the number of researchers, and strengthening the research setup. In terms of budget, a total of Y8.2 billion was expended in the initial 3-year phase, and Y4.776 billion has been earmarked for the current fiscal year.

This project has attracted great concern and expectations in Japan and abroad. Particularly, major advanced countries have adopted a similar project as their policies, and, at the same time, have sought research cooperation. In view of the policy of international cooperation, MITI is in the process of considering specific measures based on mutual cooperation.

The project is outlined below, with discussions centering on the results of the initial phase.

2. Outline of Project

Since the economic society of our country is directed at enhancing its level of information, use of computers has made rapid progress. For one thing, knowledge information systems are in great demand. The fifth generation

computer is positioned as a computer forming a core of the knowledge information system which will become the mainstream in the 1990's. Note that some 40 years have passed since the basic form of computers currently in use was created. (This method developed by Dr von Neumann is based on the thought of simplifying hardware and let software handle more work.) In other words, it gives software much of the load. This was suitable when the hardware cost was formidable. But, as the range of applications expands and as a variety of system management programs and applications software multiply, there is no denying that the software cost has become a major burden. This is why it is described as the software crisis. Furthermore, technical limitations of the von Neumann format have often been pointed out.

A concept to rebuild the computer hardware and software system on the basis of predicate logic was proposed by a group headed by Director Fuchi (of the Electrotechnical Laboratory at that time), which now plays a leading role in the ICOT research team. In agreement with this idea, MITI decided to proceed with R&D on a new type of computer with a predicate function as a national project.

Therefore, the fifth generation computer is called the predicate logic machine or interference machine in view of the basics of logic. (For a language equivalent to the machine language that determines the architecture, a language based on predicate logic is used as a nucleus language.) Since inference is a basic operation in the hardware, parallel operation and associative retrieval has become basic, and sequential operation and address type retrival of the Neumann type have become basic. Hence, this can be said as one of the non-Neumann types. Also, its software can be built by combining basic inference operations provided by the hardware. Since the nucleus language based on predicate logic is basic, software is developed from a level higher than that of the machine language. It is considered that use of these capacities can produce high functions such as the knowledge information system.

3. R&D Steps

Plans for realizing the fifth generation computer were made by dividing the 10-year period into three phases as shown in Figure 1. Emphasis of the initial period of R&D was placed on evaluating and rebuilding existing theories and technologies of the knowledge information system to develop basic technologies for the intermediate phase. The intermediate phase plan was to establish, based on the results of the initial phase, a computation model, algorithm, and basic architecture which will form the foundations of the software and hardware, thereby making a pilot model of a small-scale subsystem. In the final phase, the goal is to make a prototype of a total system after studying how to distribute the functions of the software and the hardware.

Figure 1. Phases of R & D Steps for the Fifth Generation Computer

1982 ⟷ 1984	1980 ⟷ 1988	1969 ⟷ 1991
(Initial Phase)	(Intermediate Phase)	(Final Phase)
Development of basic technologies	Subsystems (Small-scale experimental subsystems)	Total system (Prototype)

Figure 2. Positioning Research Topics in the Initial Phase

Basic Software System

* Problem solving, inference soft module
* Knowledge base management soft module
* Intelligent interface soft module
* Intelligent programming soft module

Nucleus Language

Inference Subsystem

* Parallel inference basic mechanism
* Data flow mechanism
* Abstract data type mechanism

Knowledge Base Subsystem

* Knowlege base basic mechanism
* Parallel type relational, knowledge operational mechanism
* Relational data base mechanism

Pilot Model for Software Development

4. Topics in the Initial Phase and the Results

R&D topics and their respective relationships in the initial phase are as shown in Figure 2. The results of research by topic will be covered briefly.

(1) Inference Subsystem

As for the inference subsystem which would become the core of the fifth generation computer hardware, research was conducted on the parallel basic inference mechanism, data flow mechanism, and abstract data type mechanism for purposes of developing basic technologies of hardware architecture. Specifically, a parallel inference method was first determined, then, as regards the reduction method, a pilot model of hardware simulator consisting of a software simulator on a scale of 64 parallels and 8 element processor units was made, and high-precision data collected and evaluated. Also, as for the complete copy method and paragraph unit method, a pilot model of a hardware simulator consisting of 16 element processor units was made. In regard to the data flow method, a software simulator on the scale of 64 parallels was manufactured on an experimental basis and an overall evaluation was conducted. At the same time, a pilot model of a hardware simulator consisting of eight element processor units was made. By means of these experimental machines, for each method, data concerning parallel capacity would be collected from the inference operations. As for the abstract data type mechanism, research on the nucleus language of the basic software was conducted from the standpoint of language; full-scale studies will be made in the intermediate phase.

(2) Knowledge-Base Subsystem

Together with the inference subsystem, the knowledge-base subsystem forms a nucleus of the fifth generation computer hardware. In the initial phase, studies were made of the knowledge-base basic mechanism, parallel-type relational-knowledge operational mechanism, relational-data base mechanism as the basic technologies for developing a massive knowledge-base machine that can efficiently process the accumulation, retrieval, and updating of knowledge data described in the knowledge-expressed language and nucleus language.

Particularly, a pilot model of a basic architecture which realizes parallel relational algebraic operation was made, along with a hardware function module, and built in the relational data-base machine to be explained later. For research on the relational data-base mechanism, by establishing a basic architecture concerning the relational data-base machine, a test model of a four-parallel relational data-base machine consisting of eight element processor units with a maximum storage capacity of 20GB was manufactured. It is intended that although this is an experimental system, it is to be connected to the sequential inference machine for use as a software developing tool.

(3) Basic Software System

In regard to the basic software system of the fifth generation computer, in the initial phase R&D was conducted on five topics of the nucleus language, problem-solving inference software, knowledge-base management software, intelligent interface software, and intelligent programming software.

(a) Nucleus Language

As regards the KL-0 which determines the interfacing for the hardware and software of the software developing pilot model, language specifications having target functions were designed at the end of FY 1982, while, at the same time, its experimental model was completed with that of the processing type. Compared with the conventional PROLOG language, the KL-09 is a logic type programming language with additions of four functions--structured program, relational data-base interface, parallel programming, and data checking type definition. Next, KL-1 language specifications were designed for use of an inference subsystem to be developed in the intermediate phase.

(b) Problem-Solving Inference Software

This purports to obtain information from theoretical phased research and from the pilot model of software to include the following: an arithmetic function that performs by sheer force of logic, an inductive inference function that includes conjecture based on incomplete knowledge, cooperative type problem-solving function where the system solves problems by mutual emphasis. The intended goals have almost been achieved with research continuing in the intermediate phase.

(c) Knowledge-Base Management Software

A large-scale relational data-base management program, to examine methods for combining knowledge base machine and inference machine, knowledge expressing system, and knowledge utilization system constituted the R&D topics in the initial phase. The large-scale relational data-base management program was used in making experimental programs of knowledge acquiring module, knowledge interactive module, knowledge interface module, knowledge operation module, and knowledge accumulation module. As for the knowledge expressing system, a knowledge programming language (MANDALA) which facilitates the formulation of a knowledge expressing language was designed and made on an experimental basis. In regard to the knowledge utilization system, experimental systems in editing Japanese support and in logic designing support were made to obtain information on knowledge utilization.

(e) Intelligent Interface Software

Toward the goal of realizing an interactive function between man and computer, research was conducted in the initial phase, especially, on language analysis techniques and meaning understanding techniques of natural language processing

technology, on test programs of high-level function, sentence structure analysis and of meaning analysis based on a circumstantial meaning theory.

(f) Intelligent Programming Software

With the goal toward realizing a function which can automatically convert a given problem into an efficient program (nucleus language level), research was conducted in the initial phase on modular programming basic software and designing as well as on a software verification management program to enhance efficiency with intelligent support at every programming stage in coding, testing, debugging, revision, improvement, maintenance, and management. Specifically, a logic type programming language (ESP) with an object-directed function, optimization program to improve actual efficiency of the object-directed language, program-making support management program, software-development utilization consultation system, hierarchical logic program verification system, and software reutilization basic experimental system were made experimentally and evaluated.

(4) Pilot Model for Developing Software

As a tool for developing software for the fifth generation computer, the hardware and software for a sequential inference machine were developed in the initial phase. The sequential inference machine is a firmware-based machine to support nucleus language KL-0. It comes in two types: PSI with a processing speed of 30 KLIPS (logical inference per second) and a maximum main storage of 80 MB, and a high-speed processor CHI with a host of PSI having a capacity of 150KLIPS and 256MB. Hardware specifications of the PSI are shown in Table 1, its system configuration in Figure 3. Also, hardware specifications of the CHI are shown in Table 2.

For sequential inference machine software, an operating system (SIMPOS) composed of three hierarchical levels by modular programming has been developed. SIMPOS configuration is illustrated in Figure 4, its scale being 103,420 lines in the logic programming language (ESP).

This completes the outlining of R&D conducted in the initial phase.

5. Intermediate Plan

The intermediate plan commenced from FY 1985 on the following research topics.

(1) Hardware System (Inference Subsystem)

Trial manufacture and evaluation of a parallel inference machine composed of about 100 units of element processor which can efficiently execute nucleus language KL-1. Research on an element processor architecture made up of configuration element modules on KL-1 level. Research on a parallel inference machine architecture on a scale of 1,000 element processor units to be implemented in the final phase.

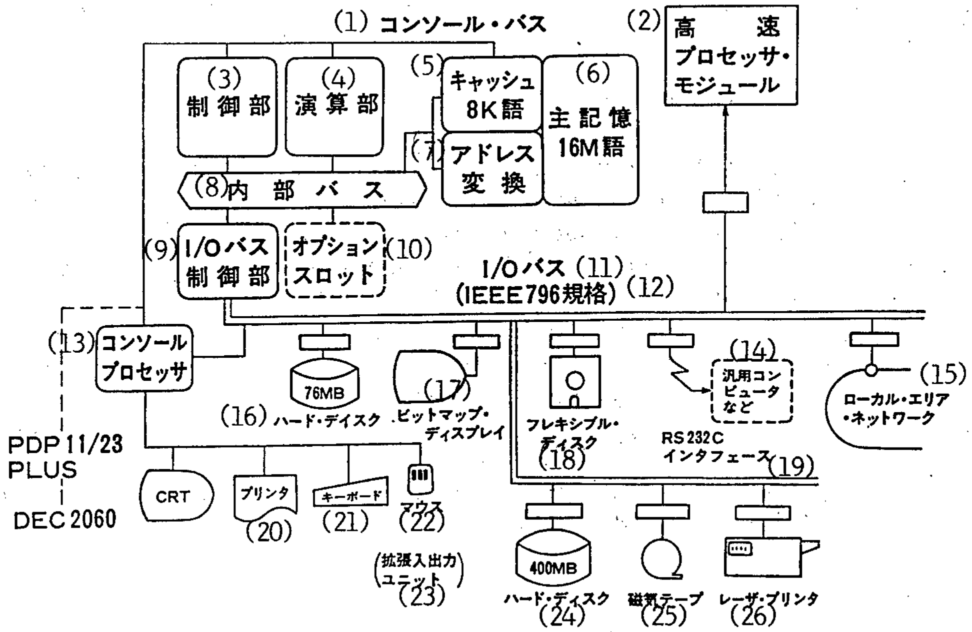

Figure 3. SPI System Configuration

Key:

1. Console bus
2. High-speed processor module
3. Control
4. Calculating unit
5. Cash 8K words
6. Main memory 16M words
7. Address conversion
8. Internal bus
9. I/O bus control
10. Option slot
11. I/O bus
12. (IEEE796Standards)
13. Console processor
14. General-purpose computer, etc.
15. Local area network
16. Hard disk
17. Bit map display
18. Flexible disk
19. RS232C interface
20. Printer
21. Keyboard
22. Mouse
23. Open-ended I/O unit
24. Hard disk
25. Magnetic tape
26. Laser printer

Table 1. Hardware Specifications of the PSI

Execution Rate	30K LIPS ~
Microprogram Memory	64 bits x 16KW
Machine Cycle Time	200 ns
Main Storage Capacity	40 bits x 16MW
Cash Memory	40 bits x 4KW x 2
Logic Elements	TTL and NMOS
Hardware Scale	CPU 12 pieces Memory 16 pieces, maximum I/O 10-odd pieces

Table 2. Hardware Specifications of the High-Speed Processor Module (CHI)

Execution Speed	150K LIPS ~(250K ~at peak)
Microprogram Memory	80 bits x 11KW
Machine Cycle Time	100 ns
Main Memory Capacity	36 bits x 64MW
Cash Memory	8KW, 4 compartment
Logic Elements	CML TTL CMOS
Hardware Scale	SCP3000 pcs, MCP70 pcs

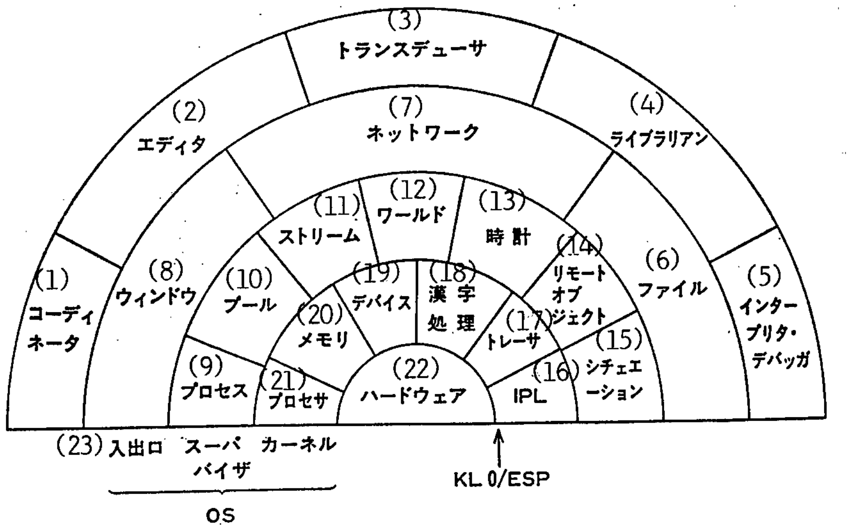

Figure 4. SIMPOS Configuration

Key:

1. Coordinator
2. Editor
3. Transducer
4. Librarian
5. Interpreter-debugger
6. Files
7. Network
8. Windows
9. Process
10. Pool
11. Stream
12. World
13. Clock
14. Remote objects
15. Situation
16. IPL
17. Tracer
18. Kanji processing
19. Devices
20. Memory
21. Processor
22. Hardware
23. Entrance/exit   Supervisor   Kernel [phonetic]

(2) Hardware System (Knowledge-Base Subsystem)

The relational data-base machine will be improved and made smaller. At the same time, research on the architecture of a knowledge base machine. Together with research on a distributive knowledge base control mechanism and on the architecture of a large-scale knowledge base machine, research on hardware algorithm for acquiring knowledge and systematizing knowledge.

(3) Basic Software

(a) Trial manufacturing and evaluation of supporting system in practical processing and program devising of KL-1, the first version for the nucleus language, and designing of language specifications for KL-2, the second version nucleus language. The KL-2 is to have functions for checking inconsistency and redundancy of KL-1 knowledge, such knowledge base management functions as inductive inference and equality.

(b) In regard to the problem solving inference software, research on parallel inference software, cooperative type problem solving basic software, and next higher inference software.

(c) As for the knowledge base management software, design and a pilot model of a knowledge expressing language for a specific domain, expansion of functions for the large-scale relational data-base management program, a pilot model and evaluation of a support system for knowledge base preparation, development of knowledge acquisition basic software and research on distributive knowledge base management basic software.

(d) As regards the intelligent interface softwares, R&D of a meaning dictionary/meaning analysis system, sentence analysis synthesis basic software, pilot model of a conversational interactive system, and pilot model for voice pattern, image interactive system, etc.

(e) As regards the intelligent programming software, research on specification description-verification system, software knowledge management system, program conversion-corroboration-synthesis basic software, pilot model for software designing-devising-maintenance system, etc.

(f) As for the basic software verification system, pilot models of several verification systems that are to be evaluated with the objective of verifying various R&D results obtained by applying them to actual systems utilized.

(4) As for the development of support systems, R&D will be conducted on a pilot model machine for developing parallel inference software, as well as a developmental support network to assure smooth progress in R&D.

6. Research Setup

Although this project had been progressing under the guidance of MITI, as to the research setup, in April 1982, a research foundation, the Institute of New

Figure 5. ICOT Organizational Chart

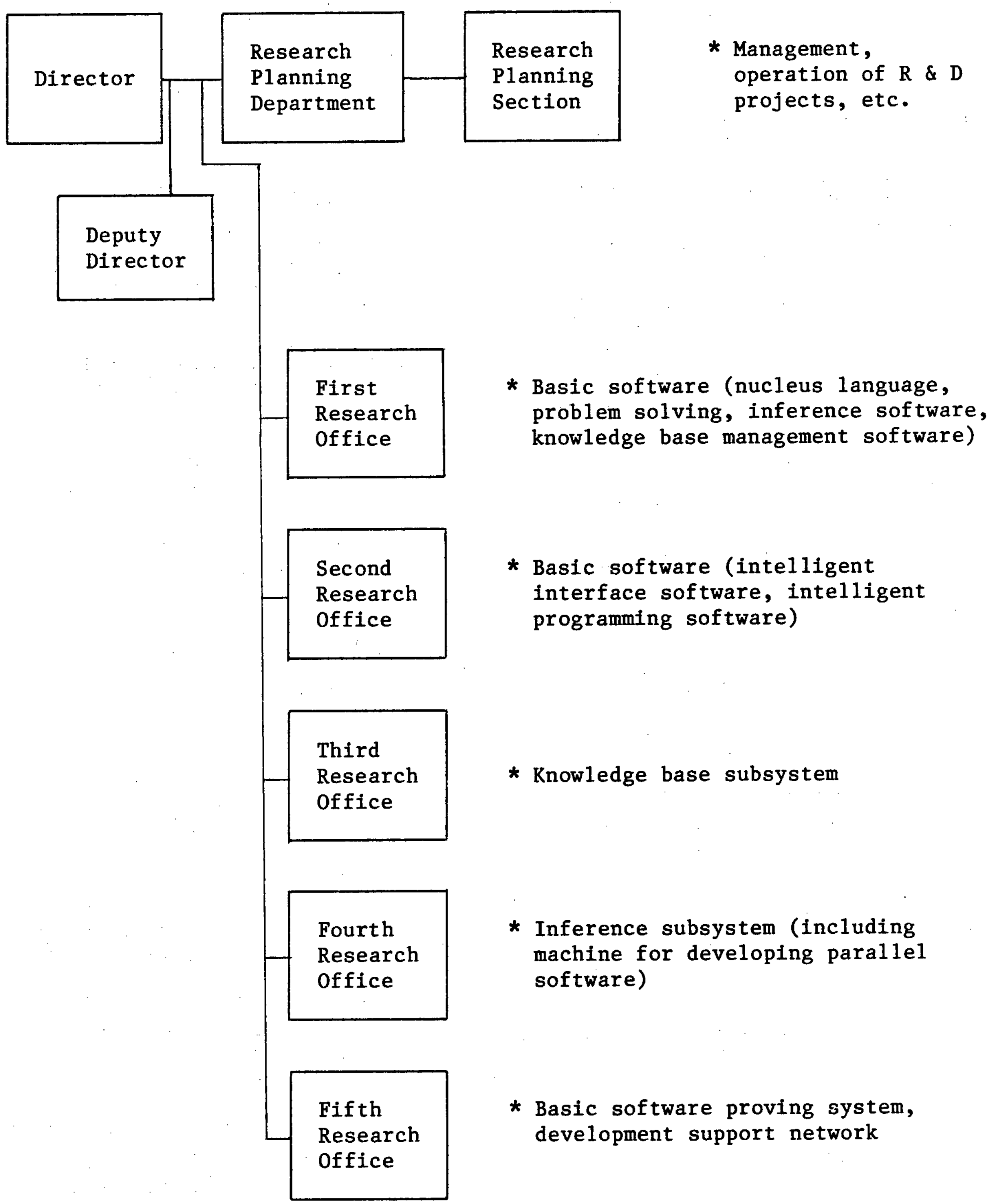

Table 3. Breakdown of ICOT Researchers by Organization

Organization	Number of Researchers Temporarily Transferred
Electrotechnical Laboratory	7
Nippon Telegraph and Telephone Corporations	6
Japan Information Processing Development Association	2
Kokusai Denshin Denwa Co., Ltd.	1
Oki Electric Industry Co., Ltd.	7
Sharp Corp.	4
Toshiba Corp.	7
Nippon Electric NEC	7
Hitachi, Ltd.	7
Fujitsu, Ltd.	8
Matsushita Electric Industrial Co., Ltd.	3
Mitsubishi Electric Corp.	8
TOTAL	67

Generation Computer Technology (ICOT), was established as the core organization where young researchers from the electrotechnical Laboratory, Nippon Telegraph and Telephone Public Corp. (currently NTT), Japan Information Processing Development Association, and eight computer manufacturers were assembled at the institute's inauguration through the temporary transfer method. Also, guidance on theoretical and basic research has been obtained through coordinating liaison with universities and national and local research organizations. Computer manufacturers cooperated in trial manufacture based on the research.

Figure 5 shows the organization of the ICOT for the intermediate phase. Currently, there are 68 researchers including the director. Researchers from companies and organizations are as listed in Table 3.

7. Conclusion

Progress in the Fifth Generation Computer Development Project has been outlined. Because of the limited space allowed, it is regrettable that this report could not cover the status of technical reports/technical memos issued, international conferences, activities of the investigation committee, etc. It is hoped that pamphlets and informational materials, etc., issued by the ICOT be referred to.

20,107/9599
CSO: 4306/1062

COMPUTER PROGRAM PROTECTION UNDER REVISED LAWS DISCUSSED

Tokyo DENSHI KOGYO GEPPO in Japanese Vol 27 No 10, 1985 pp 19-26

[Article by Kiyoshi Kakemizu, Copyright Division, Cultural Affairs Department, Agency for Cultural Affairs, Excerpts from DENSHI KOGYO GEPPO Vol 27 No 10: "Protection of Computer Programs After the Revision of Copyright Law"]

[Excerpts] Preface

"Partial Revision of Copyright Law," approved on 7 June 1985, was made public as Law 62, and will be enforced effective 1 January 1986. This revision law is aimed at making clear that computer programs are writings to be protected by Copyright Law, putting in order Copyright Law provisions so that they match the special characteristics of computer programs, and protecting the right of writers of computer programs.

Until this revision law was approved, the Agency for Cultural Affairs and MITI discussed whether computer programs are to be protected by Copyright Law or by special legislation for computer programs, such as a program right law. In March 1985, however, both government bodies agreed in protecting computer programs by Copyright Law, permitting a revision of the Copyright Law at this time.

I. History of Legal Protection of Programs

1. History of Investigations by Government Bodies

Regarding legal protection of computer programs, the second subcommittee of the Copyright Council issued a report on the computer as early as June 1973 to establish the point that programs can be viewed as scientific writings.

MITI also made public an interim report on the legal protection of software in May 1972 and proposed new legislation for program protection. Since, however, it was necessary to carefully investigate the actual state of program circulation and international trends on program protection, the ministry proposed a tentative system instead of immediately initiating legislation.

After that, no government investigation of this problem was made for some time but reinvestigation of the legal protection of programs has been requested because of the remarkable development and spread of both hardware and software in recent years. Many disputes accompanied unauthorized program copy and measures were being taken in international organizations and several countries for legal protection of programs.

Under these circumstances, the Copyright Council set up the sixth subcommittee and started deliberation on the legal protection of programs in February 1983. The subcommittee investigated the scope and problems of the protection of software by copyright law system and made public the results of investigation in an interim report on 19 January 1984. This report defined protection of programs clearly and made concrete proposals on the legal consolidation that matches the special characteristics of the protection.

Based on the proposals, the Agency for Cultural Affairs drew up a Copyright Law revision draft (Agency for Cultural Affairs' draft), made it public on 14 February 1984, and requested comments from those concerned.

MITI set up a software base consolidation subcommittee in the information industry committee of the Industrial Structure Council. It had investigated legal protection of programs, and made public the results of the deliberation in an interim report on 9 December 1983. This report proposes enactment of new legislation.

The Agency for Cultural Affairs which insisted on partial revision of the Copyright Law and MITI which insisted on new legislation differed in their ways of thinking; in the end, both decided to refrain from submitting their bills to the 101th Diet last year.

In April 1984, the economic measures ministers' conference decided that adjustments should be further delayed while the interest of international harmony is being taken into consideration on the way to better protection of programs.

When the Copyright Law was partly revised last year with regard to rental records, etc., the Conferences on Education of the House of Representatives and House of Councillors attached the supplementary resolution that appropriate legal consolidation be made on protection of computer software while attention is being paid to the international compatibility of software characteristics with treaties as prerequisites, and with opinions of related government bodies immediately adjusted. Based on the decision and the resolution, adjustment had been put forward between the Agency for Cultural Affairs and MITI.

2. Trend of Judicial Precedents

On 6 December 1983, for the first time in this country the Tokyo District Court handed down a decision on the case related to pirate editions of video games to the effect that computer programs should be protected by Copyright Law. This decision was given from the same standpoint as that of the second subcommittee of the Copyright Council and showed: 1) The program creatively

expresses scientific ideas and comes under the category of writings; 2) an object program is a copy of a source program and an action of storing an object program into other ROM (Read Only Memory) comes under reproduction of a source program.

Decisions having the same effect as that of this decision were given at Yokohama District Court on 30 March 1983, at Osaka District Court on 26 January 1984, and at Tokyo District Court on 8 March 1985 and on 10 June 1985.

3. Approval of Law Partly Revising Copyright Law

Since last May, adjustment has been put forward between the Agency for Cultural Affairs and MITI; based on the trend of court decisions, both government bodies reached the following agreement in March 1985.

(1)Revision of Copyright Law shall be submitted to the current Diet to protect computer programs and the main contents shall be the gist of the proposal of the sixth subcommittee of the Copyright Council with a new system added for registration of the computer program creation date.

(2)With regard to better protection of the right of computer programs, both government bodies shall cooperate in performing domestic and international investigations from a medium- and long-term viewpoint in the coming years, taking international harmony into consideration.

Under this agreement submission of the bill for partial revision of Copyright Law to the Diet was decided upon at the Cabinet meeting on 5 April 1985, the bill was submitted to the Diet on 11 April, and after three deliberations including inquiries to witnesses in the House of Representatives and House of Councillors, it was approved and passed.

When the bill was approved, the supplementary resolution that regarding legislation related to program registration, measures shall be quickly put forward in coordination with related quarters and the right of program protection shall be investigated from a medium- and long-term viewpoint with international harmony taken into consideration, has been attached in Councils on Education of House of Representatives and House of Councillors.

II. International Trends in Legal Protection of Programs

Legal Protection of Programs in International Organizations

With regard to investigations in international organizations, Paris Alliance (Paris Industrial Patent Treaty) of WIPO [World Intellectual Property Organization] started investigations in 1970 on protection of programs. In its second software legal protection specialist committee in June 1983, the majority of the countries which participated agreed that protection of software can be encompassed by the Copyright Law. They recommended that investigation of the conclusions of a special international agreement in Paris Alliance should not be undertaken for the time being, and decided that this

problem should be investigated from the standpoint of the Copyright Law through a joint conference of Berne Alliance (Berne Copyright Treaty related) and UNESCO (United Nations Copyright Treaty related).

In investigating the Copyright Law, a joint conference of WIPO and UNESCO specialists was held from 25 February to 1 March 1985. The majority of the countries at this conference decided that programs should be protected by the Copyright Law. A world trend toward protection of programs by the Copyright Law was confirmed.

III. Outline of the Revision of Copyright Law

1. Definition of Protection of Programs

Programs shall be clearly defined as writings to be protected by Copyright Law by adding them to examples of writings, and at the same time, regulations of program definition shall be set up.

Also, verification regulations have been set up to show that program languages, conventions, and solutions do not come under the protection of Copyright Law.

(1) Definition of Program (2 of Item 10 of Clause 1 of Article 2)

The program is "what is expressed by combining commands to a computer so that a result can be obtained by causing the computer to function."

The computer is "an electronic device that performs data processing such as operation, discrimination, etc." The basic configuration of a computer system consists of input units, main memory, a processor unit, a control unit, and output units. However, a system equipped with main memory, a processor unit, and a control unit, can be called a computer.

Therefore, not only large/medium general purpose computers, small office and personal computers, but OA devices such as word processors, etc., and microprocessors incorporated in electric devices, etc., such as electric rice-cookers, come under the category of computer.

A collection of commands to a computer is a program, but related materials, such as design documents, flowcharts, program explanations, etc., which are created in the course of program, do not come under the category of program in this item.

Commands to a computer are usually written in a program language, such as COBOL, FORTRAN, etc., and are converted to machine language which the computer can execute. The former program is called a source program, the latter an object program; both come under the category of program in this item.

(2) Examples of Program Writings (Item 9 of Clause 1 of Article 10)

It has been recognized in judicial precedents that programs are writings that are targets of protection by Copyright Law; but to make this clear, program writings have been added to the regulations of program examples in Article 10.

(3) Program Languages, Regulations, and Solutions (Clause 3 of Article 10)

The targets that Copyright Law protects are not ideas but expressions. Languages used for measures of expression and principles and conventions in the background do not become targets of protection by Copyright Law. To make sure of this, program languages, conventions, and solutions have been regulated by way of examples. Meanings of these are defined as shown below.

1) Program language

Characters and other symbols as measures to express programs and systems.

2) Regulation

Special consents on the use of program in the previous item in a specific program.

3) Solution

Method of combining command to a computer in a program.

The program language usually forms a language system as combinations of letters, digits, and symbols. To be more concrete, COBOL (for business calculations), FORTRAN (for scientific and technological calculations), BASIC (for personal computers), and ASSEMBLER, are examples.

Regulations are special promises needed for connection of a program with another program. When a program is created, it becomes necessary to obey not only the rules contained in the program language but those which are necessary for the program to be used in connection with other programs. Also, when computers are connected with a communications line, special promises related to data transmission need to be used in the program for each computer to be able to execute its programs to perform a series of processing. These special promises are called conventions.

Solutions mean so-called algorithms. The program is a concrete expression of the processing procedure necessary to obtain a result, which is the purpose of the program, as a combination of commands to a computer. The procedure of this processing is a solution.

2.Consolidation of the Regulations Related to Corporate Writings (Clause 2 of Article 15)

Creative writing formerly could be accomplished only by a human being, but Article 15 Copyright Law approves the position as a writer for a corporation, etc., when all the following conditions are satisfied:.

(1) The writing is based on the initiative of a corporation, etc.

(2)The writing is created by a person who is engaging in his duty in a corporation.

(3) The writing is to be made public by a corporation with its name attached.

(4)No special rule is contained in the contract, duty rules, etc., at creation time.

When these conditions are applied to corporate writing, the third condition becomes especially important for a program.

Many programs are being created by corporates such as enterprises, but of these programs, many of them are for in-house use and are originally not scheduled to be made public. Even if programs are made public, they are made public without names or in many cases under the names of other companies.

If such actual states of creation and use of programs are taken into consideration, it does not reflect the actual states to require the requisite of publication names on programs. For program writings, therefore, Clause 2 is set up in Article 15 to provide, "The author of a program which is created by a person, who is engaging in his duty in a corporation, etc., based on an initiative of the corporation, etc., shall be the corporation, etc. unless a special rule or special rules are contained in the contract, duty rules, etc., at creation time," to exclude the requisite of publication name.

Based on this regulation, a corporation has come to be recognized as a writer if the above requisites (1), (2), and (4) are satisfied even when a program is 1) not made public, 2) made public without name, 3) made public with another corporate name, and 4) made public with a personal name.

So far, an attempt has been made to achieve concrete appropriateness with the interpretation that an unpublicized program becomes a corporate writing when it would be given the corporate name if it were made public, but this regulation has come to legislatively make the author of an unpublicized program clear. Furthermore, when a person other than a corporate employee participates in program creation, application of the second requisite "a person who is engaging in his duty in a corporation, etc." becomes a subject of discussion.

The majority view interprets the requisite "a person who is engaging in his duty" strictly and requires the person to have a definite status relationship with his corporation, but the minority view interprets that no status relationship is necessarily required if the person is under the directions and commands of his corporation. This author's view is that in order for a person to be regarded as an employee of a corporation, no status relationship is necessarily required, but it does not suffice that the person is under the directions and commands of the corporation, and he may be regarded as a person who is engaging in a duty of the corporation if he is under the directions and

commands of the corporation to the same degree as an employee of the corporation.

"A person who is engaging in duty in a corporation" should be decided upon based on whether the person can be regarded as the same as the corporate employee after a substantial investigation of the pattern in which the person engages in a duty of the corporation.

3.Limitations on Application of Identity Retaining Right (Item 3 of Clause 2 of Article 20)

Clause 1 of Article 20 of Copyright Law provides the right of preventing a writing and its name from being changed against the writer's intention as the identity retaining right which is one of writer's personal rights. However, Clause 2 of the article provides as the case where the identity retaining right does not work that a writing and its name can be changed without the author's consent when the change is regarded as inseparable from the property and the purpose and pattern of the use of the writing.

When a program is used, usually some corrections, such as debugging, and other changes for making the program more efficient and usable are needed. Since it is difficult to say that such changes are damaging to the author, making the changes in the program is allowable without the author's consent. Therefore, Item 3 of Clause 2 of Article 20 provides, "To make a program usable on a specific computer or to make it more effective, necessary changes can be performed," in the same way as changes may be made in a building (Item 2 of Clause 2 of Article 20).

4.Limitation of Copyright on Reproduction, etc., by Owner of a Reproduction of a Program (2 of Article 47)

When a program is used, it is usual that reproduction and adaptation are made on the program as procedure to use the program on a computer or for the purpose of effectively using the program. Requiring the copyright proprietor's consent for the reproduction that naturally accompanies the use of a program on a computer may prevent impartial use and smooth circulation of the program. Also, limitation of a copyright proprietor's right on such use is not regarded as illegally harming the proprietor of the copyright. In consideration of the above, the following copyright limitation regulations have been provided.

2 of Article 47

(1)The owner of a copy of the writing of a program is allowed to reproduce or adapt the writing (including reproduction of a secondary writing created by copy or adaptation) to the extent needed for his own use of the writing on a computer. However, the case where the regulation of Clause 2 of Article 113 is applied to the use of a copy in relation to the use concerned is excluded.

(2)After an owner of copies (including copies based on the regulation of the above article) of the same article lost his ownership on one of them for cause other than loss, he shall not retain other reproductions unless the copyright proprietor specially indicates his intention.

It is for the following reasons that in this article, the copyright is limited only on the copy and adaptation performed by an owner of a copy. That is, (1) since the actual state of lending of a person who has borrowed a copy of a program depends on kind and use of the program, such as a program for general purpose computers, or that for personal computers, overall limitation of the Copyright Law on the above action is not appropriate; and (2) it suffices to determine necessary articles in a use contract, etc., for lending the reproduction of the program.

As concrete examples of the reproduction and adaptation allowed in this article, creation of a copy for loss, damage, etc., of a program copy (so-called backup copy), reproduction for change of memory medium from magnetic tape to magnetic disk, conversion of a source program to an object program and storage of the object program for use on a computer, changing a program for addition of function, changing a program for adaptation to the computer used, and so on, are thought of.

The reason why Clause 2 of 2 of Article 47 has been provided is that since it is thought unfair for a person who has reproduced a program based on the regulation of Clause 1 to be allowed to retain and use remaining reproductions even after he has lost his ownership on any of the original copies or the copy created under this regulation for a cause other than loss, such as selling the copy to another person, retention of other copies shall be prohibited.

5.Consolidation of Regulations on Use of Reproduction for Other Purposes Than Prescribed One

If a copy created based on Clause 1 of 2 of Article 47 comes to be offered and presented to the general public beyond the prescribed purpose, the copyright proprietor's benefit will be harmed. Even with limitation regulations on other copyrights, Article 49 in force does not allow use of a copy for a purpose other than the prescribed one after it has been lawfully created based on the limitation regulation, but attempts to protect the copyright proprietor by regarding the owner of the copy as having newly performed reproduction at the time of using the copy for a purpose other than the prescribed one. Since the copy created based on 2 of Article 47 is handled in the same way, the regulations of Article 49 have been consolidated.

Retention of a copy against Clause 2 of 2 of Article 47 shall be regarded as a new copy at the time retention of a copy has become an action against Clause 2 of 2 of Article 47, to secure the practical effect of Clause 2 of Article 47.

Actions to be regarded as reproduction based on Clause 1 of Article 49.

(1)Distribution of a copy (excluding a copy of a secondary writing) in violation of the regulation of Clause 2 of 2 of Article 47. (Item 4 of Clause 1)

Actions to be regarded as adaptation based on Clause 2 of Article 49.

(1)Distribution of a copy of a secondary writing based on Clause 1 of 2 of Article 47 or presentation of the secondary writing to the general public by that action (Item 2 of Clause 2).

(2)Retention of a copy of the above secondary writing in violation of the regulation of Clause 2 of 2 of Article 47 (Item 3 of Clause 2).

A case which is regarded as copy or adaptation based on the regulations of this article shall be against the copyright if the copyright proprietor's consent has not been obtained.

6.Consolidation of Regulations During Protection Period (Clause 3 of Article 53)

Clause 1 of Article 53 of Copyright Law determines the protection period of a writing with an organization name to be 50 years after announcement. (Fifty years after creation if a writing is not made public within 50 years of creation.) The protection period of a writing which comes under the category of corporate writing is determined based on the above regulation, but since the regulation of Clause 2 of Article 15 has been newly provided, the author of a program which is created by an employee of a corporation in his duty becomes the corporate independently of the publication name of the program. In some cases, therefore, Clause 1 of Article 53 cannot be applied. Clause 3 of Article 53 has been provided so that the starting point of counting the protection period of the writing of a program whose writer is a company or an organization and which was made public without name or with an individual name is handled in the same way as that of a writing with an organization name.

7. Consolidation of Registration System Related to Programs

(1) New Provision of Registration of Creation Date (2 of Article 76)

The Copyright Law in force provides the registration system of the first issue (publication) date, that is, the system of making public the time of the first announcement of a writing by registration. (Article 76)

Conventional writings, for which issue or announcement is the prerequisite, can attain copyright integrity by making the most of this registration system, but since programs are used in many cases without issue and announcement, cases where this system can be made the most of are limited.

In consideration of such a characteristic of a program, the following regulations have been provided as a new registration system for right integrity separately from the existing system, with attention paid to creation date.

2 of Article 76

(1)The author of a program can register the creation data of the writing. However, cases where 6 months passed after creation of the writing are excluded.

(2)For a writing for which the above registration has been made, creation is regarded as having occurred on the date of registration.

The application of this registration is limited to the author, because only the author usually knows the creation date.

Also, in consideration of the difficulty involved in verification of creation date, the period of application has been limited to enhance the truthfulness of the creation date related to an application. Thus, the provision has been set up so that an application is allowed within 6 months of program creation in consideration of the viewpoint of securing an opportunity of application.

Until the law to be separately provided is enforced for the program registration based on 2 of Article 78, this registration is not to be put into effect. (Additional Clause 1) Concrete items related to the registration in this article are provided in the law to be separately provided based on 2 of Article 78 or related government and ministerial ordinances.

(2)Legislation of the law related to registration of a writing of a program (2 of Article 78)

Not only creation date registration but program-related registration require various consideration in relation to program characteristics on registration procedures and the method of public announcement. Thus, since it is desirable to collectively process the problems unique to the registration of programs, a separate law has been provided. As contents of this separate law, delivery of a copy of the registration procedure program and issue of an official report that carries an outline of the name and function of the program, etc., are thought of. However, specific contents are now being investigated and a bill is to be submitted as soon as adjustment to the related quarters has been completed.

8. Regulation for Use of Illegal Reproduction (Clause 2 of Article 111)

The right of the Copyright Law in force is not effective for the use of a program on a computer.

Now, it is thought to be a subject of discussion in respect of securing a right proprietor's appropriate benefit if a large economic value which occurs from the use of a program on a computer is taken into consideration that a right proprietor cannot assert his right even in the case of the use of an illegal copy of a program on a computer for business. Therefore, to protect a program author's rights while smooth circulation of the program is being taken into consideration, regulations of Clause 2 of Article 113 have been provided to regard the action of using an illegal copy of a program on a computer as a violation of rights.

Clause 2 of Article 113

The action of using a copy created by an action of violating a copyright of a writing of a program (including a copy created by the owner of the copy based on the regulation of Clause 1 of 2 of Article 47, that of a writing of a program related to import of Item 1 of the previous Item, and that created based on the regulation of Clause 1 of the article) on a computer for business is regarded as a violation of the copyright only if the person concerned had known the circumstances at the time he acquired the authority of using the copy.

Based on the regulations of this article, business use on a computer of a copy created by an action of violating the copyright of a program is regarded as a violation of the copyright when the violator had known the circumstances when he acquired the authority of using the copy.

A case where the owner of an illegal copy created a copy based on the regulation of Clause 1 of 2 of Article 47, a case where a person imported a copy based on Item 1 of Clause 1 of Article 113, or a case where the owner of the imported copy created a copy based on the relation of Clause 1 of 2 of Article 47 is handled as a case of a copy created by an action of violating the copyright.

Application of this regulation is limited to an action for "business." The "business" is one that is continually performed based on the position in social life and is not limited to an action aimed at profit. However, an action of an individual using a copy for entertainment purposes or that of using a copy in the home is excluded.

Also, application of this regulation is limited to the case where the violator had known the circumstances when he acquired the authority of using it. "The time the authority of using" refers to the time when transfer or lending of a copy occurred or when the use of a copy was approved without transfer of the ownership of the copy. "Had known the circumstances" refers to the case where the violator had known that the copy was created by an action of violating a copyright.

9. Supplementary Provisions

(1) Enforcement date (Clause 1)

This revised law shall be enforced from 1 January 1985.

However, the revision for addition of 2 of Article 76 (registration of creation date) and 2 of Article 7 (special cases related to registration of a writing of a program) is enforced from the day of enforcement of the law related to registration of a program.

(2) Measures for transfer period (Clause 2 to Clause 4)

A writing created before enforcement of this law shall be treated based on precedents in relation to Article 15. (Clause 2)

In relation to Clause 2 of Article 113, application of 2 of Article 47 is substantially approved for a copy of a program created before enforcement of the article and Clause 2 of Article 113 is not applied to a copy which the regulation of 2 of Article 47 can be lawfully applied to and can be retained. (Clause 3)

Penal regulations are applied to an action performed before enforcement of this law based on precedents. (Clause 4)

(3) Partial revision of registration permission tax law

Along with the new provision of creation date registration, the registration permission tax of creation date registration has been determined to be Y3,000 per matter in the same way as that for the first publication registration.

20,111/9599
CSO: 4306/1508

POSSIBILITIES OF 'NEW GLASS' DISCUSSED

Tokyo NIKKO MATERIALS in Japanese Oct 85 pp 14-17

[Article by Atsushi Araki]

[Excerpts] Forum Established

Last 16 July the "New Glass Forum" (representative organizer, Tetsuo Suzuki, president of the Hoya Corporation) was established under the sponsorship of MITI [Ministry of International Trade and Industry] with a view to laying the foundation for a new glass field throughout associations of persons concerned in the industrial, academic and official worlds. Fifteen companies--relevant private enterprises such as Asahi Glass Co., Ltd., Sumitomo Electric Industries, Ltd., Nitto Boseki Co., Ltd., etc.--participated in the forum as promoters. In all, 60 companies, including companies from the chemical, optical equipment and cement fields have participated in the forum. It has been decided that a planning promotion council (chairman, Sumio Sakubana, professor at the Kyoto University Chemical Research Institute) will be established within the forum with a view to organizing the following activities, and will propose a deadline of March 1987: 1) seminar activities such as lecture meetings, study meetings, etc., 2) activities for investigating technical levels, market scale and business problems, 3) campaign for popularizing enlightenment, etc.

It appears that this organization has been eagerly awaited by persons concerned. High-function and high-value-added glass materials with a different image from the conventional one have already been put to practical use in various high-technology and industrial fields and have appeared in the limelight, but these materials are not mutually interrelated and fall into an individual concept. As long as they have something in common with each other, starting a business as elements unified to some extent in the industrial field was the desire. Particularly, among private enterprises it was also the aim in upgrading the industrial world's image in establishing an academic field that differs from conventional glass, in securing personnel who would or would not greatly influence the success of advanced technology development.

As a new industry, the actual situation has been considerably formed. In the optical field progress is being made on a group of fibers which have already

or are nearly being demonstrated in transmission and in the communication fields, silica base optical fiber, compound glass optical fiber, flouride optical fiber, etc., for low-loss optical transmission, chalcogenide optical fiber for energy-transmission and optical waveguide glass. In the magnetic field progress is being made with chalcogen glass used in optical memories, high-ionic conduction glass used in solid batteries and very-thin plate glass for display. In the mechanical and structural function fields research is progressing with highly-tensile crystal glass complex used in multiform structural bodies, photomasks for manufacturing IC's (integrated circuits), a precursor of the age, etc. In addition, the chemical and biochemical fields are conducting research on porous glass, vitrification of radioactive wastes and artificial bone and artificial tooth roots, referred to as "Bioglass".

Manufacturing Methods and Functions Changed

Incidentally, various kinds of conventional glass are available and the function (performance) according to difference of transparency, intensity, color, etc., has steadily been enhanced. However, the manufacturing methods and original functions of glass have not changed. The ASTM (American Society for Testing Materials) defines the "inorganic substance obtained by cooling and solidifying without any crystal precipitation" as an amorphous substance, and its definition is common throughout the world.

Basically, new glass is included in this definition, but there are many kinds of glass whose manufacturing method is quite different from others or whose physical properties and functions have been changed greatly by adding a specific substance. While the melting and cooling methods have conventionally been taken as manufacturing methods, now the following methods are being adopted: 1) atmospheric melting method, 2) CVD (chemical vapor deposition), 3) sol-gel transformation method, 4) metallizing and sputtering methods, and 5) super-cooling method.

New glass obtained by using the above methods possesses electric, electronic, magnetic, chemical and biochemical characteristics, mechanical toughness and heat resistance, in addition to the original characteristics of glass such as high-insulation characteristics, vessel functions and optical transparency. Photomasks are used to enhance the optical transparency of glass. These photomasks are glass substrates used for manufacturing circuit patterns of IC's on silicon single crystal wagers. Glass with high-hardness, small thermal expansion and a smooth surface is used in circuits because they are complex and have a microscopic width at a micron level. The superfine glass processing technology is required to manufacture glass for the photomasks, because the work of manufacturing such glass does not allow any microscopic flaw.

Glass containing neodymium will be used for obtaining a larger output than that of a single crystal laser in the case of laser oscillation as well because glass is excellent in formability. In addition, originally glass has

been an electric insulator, but glass containing silver salt--i.e., having a special composition--has an electric conductivity equal to that of water. Therefore, such glass is being used positively in electrode materials.

Although glass seems to be brittle, its hardness is high, and when the optical fiber is coated with plastic it will be twice as hard as piano wire. The cracking of glass is caused by microscopic flaws on the surface of the glass, and when such glass is subjected to surface treatment it will be strengthened. When the elastic modulus is increased, the glass can be used a a structural material.

Moreover, the mechanical workability of glass can also be enhanced. When a microscopic crystal such as that of mica or the like is precipitated on the glass, the crystallized portion will crack in flakes. Accordingly, this matter will be able to prevent cracks from occurring and will simplify the drilling work and cutting work with a saw and a lathe. This glass has been used practically in tile holding plates of the space shuttle, etc. Also, when glass containing zinc is treated in an autoclave, it becomes hydrated glass containing about 50 percent water. Molded parts with the same smoothness as that of the polish ones can be obtained by pressing the hydrated glass at temperatures of 200 to 300 degrees centigrade, because the hydrated glass has plasticity.

When part of the borosilicate glass is eluted, porous glass forms pores with a radius of 1 to 3 nanometers. This porous glass can be used for separating an organic solvent medium, gas at high temperatures and a catalyst carrier for exhaust gas generated by automobiles. It can be also used as a reverse osmotic membrane for desalinization.

As mentioned above, glass is reformed by various methods and is being put on a new market as a high-function and high-value-added material.

For example, the optical computer has come into the limelight as quite a promising subject for the future in the electronic field in which the solar battery substrate, optical fiber, etc., are handled. As another example related to energy, research on the use of glass as a separation film used in the C_1 chemical field is being conducted. With regard to thermal members, there is a glass with a thermal expansion coefficient of zero. Accordingly, it is possible to use the glass as an element of heat exchangers. In addition, the study on composition of ceramic engines and glass is being conducted to strengthen them.

Optical Fiber, Photomask, Memory...

The IC, which is a main product in the present industrial world, is designed and structured by using electric signals. The appearance of an optical IC which will optically carry out operations has been eagerly awaited with a view to enhancing information processing speed. Optical waveguides are made on special glass substrates of the optical IC. Such an optical IC is composed of an integration of optical circuit elements of a photodetector,

optical modulator, optical deflector, optical branching filter, etc. Although there is still a long way to go toward practical use of the optical IC, the optical IC is said to be a suitable subject for establishing the position of new glass in the future.

New glass is expected to have a great future as a material for mass storage devices. The increase in memory capacity is inevitable in proportion to the increase in information content. Although the crystallized membrane of chalcogen glass has already been used as an optical memory, it has not yet been able to carry out rewriting work freely. If it is possible for the membrane to carry out the work, there will be a strong possiblity of the membrane being widely used as material for optical memories. Recently, transparent plastics such as PC (polycarbonate) and PMMA (polymethylmethacrylate) have been used as materials for optical memories, but memories which require higher accuracy will probably be based on glass. Particularly, memories of computers and mass-produced (memories) negatives for copying machines require high accuracy.

The complex of high-intensive glass and crystallized glass is widely used in mechanical parts and structural materials. The strength and toughness of this complex are much higher than those of usual glass. Crystallized glass was developed by Corning Glass Works in the United States. It is manufactured by forming glass containing 2 to 20 percent titanium oxide, reheating the glass, making many crystal nuclei and promoting crystal growth around these nuclei. Originally, glass has no crystal structure, but it has been reported that transparent crystal glass manufactured in accordance with the above method is lighter than aluminum and harder than steel.

The complex as a new glass will be reinforced with silicon carbide fiber, etc. In this case, the adjustment of the reaction of silicon carbide and glass will become a problem. Attention will have to be given to the comparison and competition with fine ceramics.

Porous glass will be widely used to separate gas and as an oxgyen carrier and a tissue culture carrier. Some of the porous glass has already been put to practical use, and it is anticipated that the porous glass will further be widely used in new fields by extending the scope of pore opening, enhancing alkali resistance and increasing multiformity of shape.

Bioglass is a material which uses crystallized glass and glass with excellent biocapability in artificial bones and artificial tooth roots. It will compete strongly with ceramics. Persons concerned in the new glass field expect the glass ultimately to be suprior to ceramics.

At present, the most popular new glass product is optical fiber. Optical fiber is mainly available in two kinds--silica base optical fiber and multicomponent base optical fiber. From now on the advent of "ultra-low loss optical fiber" will be expected. In the case of silica base optical fiber, infrared light with a wavelength of 1.6 m has a considerable optical

loss factor of 0.2 decibel per kilometer. This is very close to the theoretical limit value. Namely, there is little room for further improvement of the silica base optical fiber. But, when future intercontinental, very-long-distance optical communication is considered, it will be necessary to adopt the optical fiber with the smallest optical loss.

One optical fiber is the fluoride optical fiber. It is thought that theoretically fluoride glass does not absorb light from infrared light of about 3 m. Also, chalcogenide optical fiber has appeared in the limelight as a laser beam fiber or an energy transmission fiber. Research on fluoride glass has just started. If fluoride glass is put to practical use, there is no doubt that it will bring about great progress in the laser machining application field.

The new glass age has just arrived!

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CSO: 4306/3562

REACTION TO U.S. URANIUM ENRICHMENT STRATEGY DISCUSSED

Tokyo ENERUGI FORAMU in Japanese Aug 85 pp 74-79

[Forum article by Shunsuke Kondo, professor, Tokyo University; Takao Ishimoto, vice chairman, Board of Directors, Power Reactor and Nuclear Fuel Development Corp.; and Masatoshi Toyoda, vice president, the Tokyo Electric Power Company, Inc.: "How Should We Interpret the U.S. New Strategy for Uranium Enrichment--Stir Generated by Adoption of the Laser Enrichment Method and Japan's Response." An installment in a "Series of Discussions on the Era of 20 Million kw in Atomic Power Generation"]

[Text] True State of Affairs Challenging the 21st Century

Kondo: Speaking of uranium enrichment service, Japan has been aiming at a stable supply. During the 1970's, Japan attempted to cooperate with the United States--to have cooperative research in order to invest in the United States. However, this attempt was not successful due to the state of affairs in the United States. Rather, a policy of domestic manufacture was adopted in view of technical progress accomplished mainly by the Power Reactor and Nuclear Fuel Development Corporation (PNC).

PNC started work on a prototype plant, and the private sector has also organized a new company. Plans are to start with about 150 t SWU per year in 1991, which will be expanded to about 1,500 t SWU per year.

Under the circumstances, France held a seminar on laser enrichment technology in May of 1985. It announced that the next generation enrichment method for France will be the laser method and that the French are planning to construct a demonstration plant of 100 t class by the year 2000.

The U.S. Department of Energy (DOE) announced in June that the next generation enrichment method is the laser method, and that it plans to construct a demonstration plant of 100 t class by 1987, and to construct a plant of 12,000 t class between 1995 and 2000. At the same time, it announced that a project for the centrifugal method at plants already under construction will be discontinued. What do you think led to such an announcement?

It Aims at $30/SWU

Toyoda: Until about 1974 the worldwide U.S. share of uranium enrichment was 100 percent. Recently, however, partly due to a rise in U.S. costs in comparison to Eurodif or Urenco in Europe, and also to nonflexible conditions for enrichment contracts, its worldwide share dropped to 47 percent in 1985. Aroused by this DOE decided to adopt several policies to realize viable world prices.

First, it tried to reduce the operating cost of gas diffusion plants currently in operation. In addition to cost reductions achievable by a cut in personnel, DOE tried to reduce costs for electric power, since 80 percent of the operating cost of a gas diffusion plant is from the cost for electric power. By the use of seasonal peak power, weekend peak power, midnight power, and so forth, through cooperation with electric power companies, the cost for electric power, $67/SWU in 1982, has been brought down to $56/SWU in 1985.

Moreover, DOE hopes to reduce further the cost of electric power by discontinuing operation of the Oak Ridge plant, whose cost for electric power is the highest. DOE also plans use of interruptible power, that is, power that may be disconnected on 10 minutes' notice, at its two other plants.

In addition, DOE is attempting, from a long-term viewpoint, to reduce prices by adopting high technology. Here, high technology includes the laser method and the centrifugal separation method. Technological development for neither has yet reached a level that can be introduced on a large scale. Of these two, however, the laser method seems more likely to require less cost for technical development, for construction, and per unit separation work. Moreover, the laser method offers possibilities of further cost reductions through significant improvement of the method in the future.

That is, the laser method presently costs about $40 per unit separation work. Workers in charge of development state that it is possible to reduce this to about $30, considering future improvements. The DOE authorities, however, estimate the cost at between $50 and $60, with some reservations.

In contrast, costs for the centrifugal separation method, at present, are estimated at from $50 to $57 by the workers in charge of development, and at $60 to $62 by DOE authorities.

Taking future procurement into account, the laser method is said to be manageable within the income that can be anticipated from the enrichment business. In contrast, the centrifugal separation method is said to require further governmental or outside assistance.

Moreover, the unit cost for the centrifugal separation method, of cost reduction is attempted by use of the gas diffusion method mentioned earlier, will be comparable to the increment in costs from increased demand for current gas diffusion plants. Therefore, incentives for constructing additional centrifuges will be rare. I suspect that this is the reason for choosing the laser method in the United States.

Defeat Declaration of Large-Scale Centrifugal Method

Kondo: This decision to adopt the laser method may have to be viewed as one element in such a policy package. However, if I may express my personal feeling, the laser method that has been widely regarded as being in the research and development stage in the United States has finally reached the pilot stage there. In other words, my impression, as an engineer, is that what has been anticipated is, in fact, finally here.

Another thing is the following: the enrichment business is currently taken care of by the United States and France. They share the world market with a production capability of about 20,000 t SWU by the United States and 10,000 t SWU by France, with severe price competition. The thing that I was made to realize anew is that, as an element of market policy, this business possesses a long-term investment character that requires decision and announcement on the technology 10 or 20 years ahead.

Amplifying this a little further, I think that we had better notice that these announcements included the intention of giving a certain message to the second group of countries that possess enriched programs.

Ishiwata: Whether the United States or France, both possess considerable accumulated capabilities. I think that they arrived at the decision that the next technical development should be the laser method, based on their recognition that they can carry it out for the time being.

In Japan, the centrifugal separation method has been under development, but has not yet reached the world market in a major way. Therefore, it is not easy to understand why the United States has been forced to give up the centrifugal separation method. However, it may perhaps be true that the effort on the centrifugal separation method by Eurodif or other laboratories had considerable impact on the United States.

As for technical trends for the centrifugal separation method, the inclination in Japan and Europe is for mass production by small machines, in contrast to the trend in the United States toward large-scale machines. In the United States, the life per centrifuge is said to be about 4 years. Although it is said that the machine is operated with necessary repairs, the capability per centrifuge is very high.

In Japan, mass production is underway, although the capability per centrifuge is not so high. Moreover, the machine is maintenance-free for 10 years. In other words, a system is adopted in which, once the machine begins to operate, it will continue for 10 years.

Improving capability by using large numbers of small machines used to be the special field of Japan. That the United States was unable to accomplish satisfactory results in the area of centrifugal separation technology, although it should not be termed a failure, seems to be tacitly admitted in recent U.S. appraisals of this technique.

If considered as a technology for the next century, however, it is true that the laser method is undoubtedly an extremely useful technique. The choice made by the United States, focusing on this point, seems logical. However, one uncertainty is whether the laser method can be developed so easily. Anticipation among people directly involved with its development seems to be very high, but I feel that a considerable number of technological problems still remain that have to be overcome before it can be commercialized. One advantage for the United States is its possible linkage with military technology. In the case of France, too, a similar situation may be true, although the scale may be different. I also think that we should consider what is implied in the fact that the other European countries are receiving the situation relatively coolly.

Toyoda: I was able to see actual developments first-hand at the Lawrence Livermore Laboratory in May. Given a tour of the laboratory by, and listening to, a Mr Davis, one with a position of the highest responsibility, and judging from what I saw there, I felt that they have considerable confidence in what they are doing. They told me that the plans are to have demonstration tests for 1,000 tons by 1987. Although it may be premature to presume anything definite without seeing any results, it seemed to me their confidence was considerable.

Since they invested a great sum of money before deciding to discontinue development of the centrifugal separation method, I have been thinking that they might yet continue development of centrifuges, albeit at a slower tempo. Judging also from this decision, I had a feeling that they must have considerable confidence in the laser method.

Now, speaking of technical development of the laser method, I think that there are three tasks that have to be accomplsihed. First, to increase the output and prolong the life of the laser. Second, to increase the output and prolong the life of the electron beam for the uranium evaporator. Third, to develop a uranium collection technique and materials that can withstand corrosion.

Although research on lasers for military purposes are also in progress at Lawrence Livermore Laboratory, the laser they are most concerned with is the copper vapor laser, which I think is different from the laser for the strategic defense initiative (SDI). They have already succeeded in increasing the output to some several hundred watts and in prolonging its life to approximately 1,800 hours. Since, however, the life of the electron beam is in the range of only 200 to 300 hours, it seems necessary to aim at extending its life still further.

The uranium collection technique is the most important part of all. Although I was actually allowed to inspect the interior of the separator, of which the electron beam generator and the metallic uranium pot were still intact, the collector portion was dismantled and had been moved elsewhere. It might have been that they decided not to show that part because there is room for further improvement of it. At any rate, they kept the most important part secret and did not even tell me about the material.

Based on these observations, my impression was that Japan may have technological advantages except in the field of collection techniques. Speaking of lasers, research has been going on in Japan, for a long time, on special discharge tubes. As to the electron beam technique, we have a history of having made high-output vacuum tubes. With respect to the actual materials, (prisms, glasses, pigments, and so forth) that they are currently using, those are made in Japan. Therefore, unexpectedly with a concerted effort, it might be possible to catch up with the United States soon.

In addition, Davis was saying that, apart from the copper vapor laser, what is required is to buy what is on the market and then assemble it, which is the area of know-how.

Kondo: If you go to the Los Alamos Laboratory, you will see a gigantic accelerator for producing mesons called LAMPF. People at the laboratory assert that that machine gave rise to laser enrichment technology. That is, the development of a device for the most fundamental research of large-scale accelerators can spread significantly.

On the other hand, except for the copper vapor laser itself, it is certainly the technology of the private sector for tuning, as was pointed out by Mr Toyoda. This is probably because beam technology is being utilized ingeniously for nuclear fusion research, LSI manufacture, and so forth.

Spur on the Heated Uranium Enrichment Market

Kondo: The next question is whether or not the present decision will make any substantive impact on the enrichment service market of the world. If so, when will the impact begin to show its effects? According to an investigation of world demand for enrichment service, it may or may not exceed 50,000 t/SWU around the year 2000. If so, we will be able to cope with that by using existing facilities. Under such circumstances, what about the incentive to build new plants by deliberately stopping those now in operation? Although there would be no question if the operating cost were unusually high, the cost may be reduced considerably by proceeding along the lines expressed by Mr Toyoda. DOE may be estimating that the cost may be further reduced.

On the other hand, we hear rumors that France is doing business at a price below 100 tons per SWU. Therefore, considering the anticipated cost under the laser method, I think it is inconceivable to give any credence to the price, unless the scale were to exceed 50 percent of the supply force. So, there may not be any new investments unless there is an unusually promising policy. In that sense, I believe that it is necessary to watch the future course of U.S. society.

On the other hand, if such a time did come, we ought to be thinking about its significance. For one thing, as is often computed, if the price of enriched uranium becomes extremely low, then the cost of the fuel cycle for light water reactors will decline. In those circumstances practical use of the fast breeder would be further delayed.

Moreover, this would strengthen the U.S. theory that the "once-through" system is most economical. One might take the view that the material facts are advantageous for the United States, facts that are confusing for Japan, in connection with the argument involving nonproliferation of nuclear power.

Next Focus Will Be on 1988 and 1989

Ishiwata: Undoubtedly, the supply and demand situation of uranium is currently lackluster. Since the announcement was made during this kind of period, it did not generate much excitement. Had such an announcement been made during a period when the situation was tight, it would have created worldwide agitation, at least psychologically. What I am hoping for is that supply and demand of uranium will again be insipid when the laser-enriched product makes its appearance in the world.

It should be noted, however, that the present period is not a choice one, but this conclusion must have been reached by the United States as a result of choices made over the past several years. Until immediately before the announcement, I had been imagining that there might be about 20 percent of the funds available for research on the centrifugal separation method, but this definite decision makes me feel that it is a method typical of the United States.

In one way, I think that this decision might have been a fairly pathetic one, although they have reached it with considerable confidence. Since one project is to be kept while the other is to be discarded, it means that the centrifugal separation method in the United States was so unsatisfactory that it had to be abandoned. I am being rather severe because I think that their policy choice might have been reached in this way.

Toyoda: As for the fast breeder, its raison d'etre lies in a rise in the price of uranium due to tight supply and demand, since enrichment is about 20 percent of the fuel cost. The significance will have not much to do with a slight reduction in the enrichment cost. Although I myself do not anticipate that such a situation will arise within the next 30 to 40 years, I think the supply and demand of uranium may become tight, giving rise to a price hike. Since fast breeders will surely have been put to practical use by that time, it is necessary to promote their technical development steadily from the present.

As for enrichment, the cost in the United States is currently about 20 percent higher than in Europe. The U.S. share is falling and there is a feeling of crisis. Because high technology is not available immediately, cost-cutting efforts are centering on use of the gas diffusion method for the time being. They might be expecting that this alone will bring the cost to $90 to $100 within several years. In that sense, there is no need for adopting high technology hastily.

In particular, if the centrifugal separation method has little price advantage over the gas diffusion method, there is little incentive for continuing technical development to introduce the centrifugal separation method. This is the reason for concentrating solely on the laser method.

Given the forecast that the laser method will be able to bring down the price considerably, and in view of demand, it seems that the United States may be able to satisfy demand with the two plants: Portsmouth and Paducah. Although haste may not be required to reduce the cost, I feel that they may try to introduce the laser method by the middle of the 1990's. That is, if they gain confidence for a lower price through a laser method demonstration within 2 years.

Ishiwata: No doubt the demonstrations set for 1988 and 1989 are attracting the attention of the world. Depending upon development by that time, however, things may be in an uproar. Althogh it is currently possible to handle demand, it is not possible for the United States to forestall the European offensive. Since the U.S. share will drop further, I wonder if they are considering dealing with the price by some policy means. Especially given a difference in price of about 30 percent.

Toyoda: The United States is hoping to be able to continue to attract customers by reducing its prices to $90 or even $80. For the time being they are thinking of lowering overall costs by such an arrangement. Beyond that, I think that they are thinking of offering a price below that of the European countries through use of the laser method.

Kondo: They say that the incremental cost would be about $45. If we believe this, then it means that the United States will break even if the customer who is willing to pay $135 for the first 70 percent pays $45 for the remaining 30 percent. This would be a current production cost of about $110, which is still higher than the European cost.

How We Should Reconstruct Japanese Strategy

Kondo: Now, the question is what Japan should do under these circumstances. I think that Japan is not in the position of a major supplier, but is in a position similar to that of the United Kingdom, France, or West Germany. In other words, from the viewpoint of guaranteeing security, Japan has been using domestic technology for a portion of the plant, which fact I think has been accepted internationally.

It is worth noting that France is buying the services of the United States and the enrichment services of the Soviet Union, in spite of the fact that it is producing uranium at plants with 10,000 ton capacity. That is, France is vigorously diversifying its supply even though it has plants with a capacity that surpasses its own demand. Therefore, I believe Japan's policy of constructing plants using the centrifugal separation method that it developed, need not be affected much by such recent movement. I think Japan plans to reduce future costs by use of the laser method, to bring prices below the European price.

Ishiwata: I think that Japan should not and will not be affected by such movement. The idea that a portion of the fuel cycle be driven by domestically developed technology, from the viewpoint of guaranteeing security, is accepted as national policy. I do not think that this will be shaken by this decision.

Contemplating the period extending to the end of the century, I think that there are three important questions. First, how far can the U.S. laser enrichment technology be developed during the present century? Second, what is the U.S. trend in the supply price, and to what extent will it affect demand and development in Japan? Third, can laser enrichment technology in Japan, with a concerted nationwide effort, catch up with the United States by the end of the century or shortly thereafter?

Important in this connection is what kind of cost can be achieved within the century by the use of the centrifugal separation method so far developed. According to the United States, though perhaps a conservative estimate, a cost for separation work of from \$50 to \$60 is cited, with practical use around 1995 assumed.

If the announcement is to be believed, we can forecast that a cost of that order may be possible with the centrifugal separation method in Japan. If it is on the order of \$60 at the end of the century or shortly thereafter, we may be able to compete with the United States. However, two scenarios are most fearful. First, a sudden price drop due to unexpectedly successful development of the laser method in the United States. The second is the situation in which laser development in Japan fails to catch up. In thinking of Japan's future plans, I think that the possibility of these two occurrences must be an important consideration.

Timing for New Materials

Toyoda: With the adoption of the laser method by the United States, it will take more than 10 years before Japan can catch up on this technology. Therefore, I think Shimokita will concentrate on the centrifugal separation method. However, I also think a problem remains in choosing between a new material and metallic barrel which is under development by the Power Reactor and Nuclear Fuel Development Corporation (PNC). The metallic barrel has a capability sufficient to compete with other methods in the world. However, the problem is to bring the price down to an international level.

If Shimokita adopts the metallic barrel method in its initial stage, it will require building a manufacturing plant for the method.

Considering repayment of construction costs for the plant, they will have to use the metallic barrel method for about 10 years. Should the laser enrichment method become practical soon thereafter, there will be no need for a new material now.

Thus, for the second enrichment plant, it is necessary to decide whether the centrifugal separation method or the laser method will be employed. We also must consider development of laser enrichment technology. That is, there is a problem of which one to choose.

Ishiwata: Given present techniques for the metallic barrel method, one has to admit that it cannot compete with the laser method, if development for the latter proceeds satisfactorily. This is because it is already hitting

the ceiling. Since the PNC is already developing a high performance machine based on new materials, they will have to introduce it to Shimokita as soon as possible.

The biggest question is whether a mass production system can be sustained, as was pointed out. If an investment takes that aspect into consideration, it may be possible to introduce a separation centrifuge with a rotating drum of a new material.

If this is not done, we cannot achieve a figure on the order of $60 during the first decade of the next century. Since the mass production system is about to be introduced, we must ensure the system's competitiveness for the end of the century. A carefully considered investment must be made on the assumption that the materials for the rotating barrel will have to be changed along the path of development. Otherwise, conditions will deteriorate in conjunction with how well it can be matched with development of the laser enrichment method in Japan.

Toyoda: Manufacturing facilities for a rotating metallic barrel and for a rotating barrel with new material will be entirely different, I think. The assembly in the later stage may be a different story. If one facility is to be abandoned, changed to the other material after a very short use, then the question is whether the makers will "OK" such a change. If Japan has to do research and development for both metallic barrels and new materials as well as for the laser, research and development costs will amount to a considerable sum. Under such conditions, the question is whether or not it will be possible to have a manufacturing scale that can actually recover costs.

Ishiwata: We have terminated research and development for metallic barrels, and emphasis has already been placed on development of high performance machines that use new materials.

Toyoda: You are now constructing a demonstration plant (DP), am I right? I think that you can be internationally competitive if you carry out a second series of demonstrations using new materials with high performance functions. Shouldn't we, however, examine whether such things can actually be accomplished?

Ishiwata: The present DP project has been pushed with the understanding that one half of the construction costs be shared by the electrical power industry. To reexamine the project at this time is.... It may be possible to change the DP project if an agreement with the electrical power people can be reached. However, various difficult problems remain. I wonder if it is possible to develop in time a high performance machine using new materials, without delaying the present schedule for the DP.

If that can be done, it will be possible to use a high performance machine from the beginning of the Shimokita plant. According to the PNC, this is impossible, but we think that, with some effort, we can introduce it in the intermediate stage of the Shimokita plant.

Development of the Laser Method in Japan

Kondo: Now that it is clear that both parties clearly recognize the state of affairs, what about the problem of technology transfer in connection with this method?

Toyoda: We think that there should be measures for technical transfers to a manufacturing company, to be erected later, or to the atomic fuel industry. In addition, we feel that it may be desirable to carry out research and development for high-performance machines in an arrangement which more closely unifies the PNC and the makers. I think that it might be necessary, in order to put an economical, high-performance machine into practical use soon, to communicate the operational data to the makers, to carry out improvements and development together.

Few Qualified Personnel and Scattered Organization

Kondo: Another important factor is how we deal with the laser method. Here, too, there are various ways of thinking. One plan is to carry it out according to the existing PNC plan. In other words, carry it out as a national project since it surely is a new technology. An opposing view, is that it will be necessary to develop with its own internal research and development capability, since the enrichment service is about to become a commercial venture. By nature, no enterprise can be started based on assurances, given by others, that, as a result of technical development, it is safe. In that sense, even though basic research on the laser method should be carried out by Japan through the Institute of Physical and Chemical Research and the Atomic Energy Research Laboratory, from the pilot stage on, it should be carried out by industry on its own. If further assistance is necessary, it should be given appropriately. I think that there are two available approaches. An approach under PNC's existing system and another which utilizes the private sector. What do you think?

Toyoda: In addition to the need for raising the tempo considerably, it will be necessary, even if it is taken care of by PNC, to recruit qualified workers. This is due to the fact that it is a different technology than the separation centrifuge, and other problems (funds, etc.,) are also different. Since basic research is also necessary, although we should make active use of private industry power, I think that we should request the Atomic Energy Research Laboratory to continue research currently underway.

A combined effort by the Atomic Energy Research Laboratory and the private sector should assure an efficient and intensive application of funds and personnel. From now on, measures for achieving its earliest possible practical use have to be examined by a combined effort of the government and private sector.

Ishiwata: I completely agree with you. Since it is a technical development with limited conditions, I think that we should begin as soon as possible. Focusing our attention on laser enrichment in Japan today, we see that researchers and related engineers are few and scattered. Rather than

concentrating them in some particular place, the best way would be to start the work by finding the method best suited to present conditions.

In that sense, it will be of no use unless we take an approach different from the past. It will bring to a standstill the nuclear fuel cycle in Japan, which was once about to take off. A time limit of some 15 years is already known. It is necessary to move quickly by finding the best approach as soon as possible through the combined effort of the government and the private sector.

Although it may not be quite appropriate to cite the metaphor, "thinking while running," we had better perhaps follow this in view of the need for training necessary personnel. Since it represents one technology system, it will be incomplete if there are any omissions. In view of this, when we think of a way to integrate the scattered force which currently exists in the private sector, I think that assignments could be determined almost automatically. In other words, we must commence from the situation as it now is.

In some areas of development, I hear that they want to introduce foreign technology. In reality, however, I doubt that such can be done for the time being. Since a time will come when Japan, having advanced, can make its own decisions, I gather that it would be best to wait until such a time. There are too many indeterminates to draw a single line, in one stroke, along which we should proceed. We have to proceed steadily by revising our plans every 3 to 5 years. Since we have to agree that personnel for laser enrichment technology in Japan are few, we cannot afford to take off at full speed in the beginning. Our progress must be such that we manage to achieve our goals by the end of the century, through accelerating gradually while gaining power.

Kondo: Do we not require an organizer at some stage?

Ishiwata: It will be necessary. However, we have to think also of the present situation, in which we have companies in the business. The sole organization that demands the technology, too, does exist distinctly. I feel that things will sort themselves out without discussing a system where who does what.

Laser Technology With Wide Applications

Kondo: The isotope separation technology does not have its only application in the field of uranium enrichment. We frequently hear "cobalt-free," but there is a possibility of exploring a new materials industry, "isotope tailoring," obtaining uranium materials which have unnecessary or harmful isotopes for atomic energy removed. Of course, the market at present is decisively the uranium enrichment field. However, considering the spreading effects that accompany the development of other related technologies, I feel that it would represent a worthwhile field for private sector investment. It will be important to emphasize this incentive.

Ishiwata: When seen not only from the viewpoint of uranium enrichment but also from isotope separation, it is a very interesting technology. Even restricted to the atomic energy field alone, there are all kinds of possibilities if we are able to manage the laser technology well. In the extreme, rumors suggest that it might become possible to attain advanced technologies for reprocessing spent fuel and high activity wastes. We must raise it as one of the basic future technologies. I think the object for the time being will be uranium enrichment.

Kondo: The only thing that worries me is that the laser enrichment technology is to take out, in principle, uranium 235. In other words, it may be an extremely sensitive technique. I think that it will necessarily lead to a controversy over whether it is right to leave such a sensitive technique to the private sector.

Toyoda: Although it may be possible to achieve 100 percent with a small-scale machine, in reality, it will be difficult to attain a value above 20 percent. At the Lawrence Livermore Laboratory, too, it is about 4.5 percent.

Ishiwata: I have been worrying that the safeguard requirements might become very strict. However, it is said that exactly 4.5 or 3 will be obtained if it is set to 4.5 or 3 at the designing stage. This would not put out highly enriched uranium unless the machine is tampered with.

Kondo: With a centrifuge, the separation coefficient of the first stage is roughly fixed so that its safety can be judged by examining the cascading situation. However, what about the present case? I feel it may be somewhat more complicated for this case since it is a collection system problem. However, can we afford to reveal the design and construction to the IAEA?

Ishiwata: Obtaining approval from the IAEA at the design stage involves the risk of exposing the technology. Therefore, I suspect that a system will be devised in which the countries possessing laser enrichment technology can get together and mutually confirm the technology. In this sense, it will be necessary for Japan to establish a development policy as soon as possible, and get started quickly.

Kondo: Thank you very much for the discussion today.

20121/9365
CSO: 4106/5033

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